The Effect of Caffeine on Performance

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Abstract

The purpose of this study was to investigate the effects of caffeine on reaction time, as measured by PEBL2 software. To test this relationship, participants were measured across three tests within the PEBL2 software, with one group of participants receiving a 300 mL dose of caffeinated coffee before testing, and another receiving a 300 mL dose of a decaffeinated coffee. It was hypothesized that the participants who received a dose of caffeinated coffee would perform better and thus have faster reaction times than those who received the decaffeinated control. The results did not support the hypothesis: the mean response time was the same across the caffeinated and decaffeinated conditions. The results of this study are discussed in relation to other findings on the effects of caffeine on performance, specifically the relationship between caffeine and reaction time.

Keywords: caffeine, reaction time

The Effect of Caffeine on Performance

A substantial percentage of the world's population consumes coffee, or other caffeinated beverages, daily to increase their ability to maintain their level of vigilance (Mitchell, Knight, Hockenberry, Teplanky, & Hartman, 2014). There are other supposed benefits of caffeine, but stimulation is the typical reason for its consumption. When tired, a person can drink caffeine and achieve an enhanced ability to maintain concentration. But does caffeine actually have the intended effects we think it does? It is this question that has, over the course of time, spurred researchers to investigate the effects of caffeine on vigilance, mood, and arousal. Many of these studies explored the impact of caffeinated beverages versus decaffeinated beverages on cognitive vigilance tasks. The findings of such studies typically show reaction times that are numerically faster, but not statistically so, in the caffeinated conditions (e.g., Amir et al, 2001; Durlac, Edmunds, Howard, & Tipper, 2002; Schneider et al., 2006; Smith, Whitney, Thomas, Perry, & Brockman, 1997).

Smith et al. (1997) investigated the impact that stress has on reaction time after ingesting caffeine and demonstrated that caffeine did help maintain alertness and performance efficiency. Specifically, the researchers investigated the effects of caffeine on psychomotor tasks using a between-subject design that measured participant reaction time. Examples of psychomotor tasks used included simple reaction time tasks, five-choice serial response tasks, and pegboard tests. These tests operated by requiring a participant to maintain a high level of focus while waiting for a specific stimulus to appear or change before responding in a previously determined manner. In one of the reaction time tasks, computer software was used to display a box on a screen. When a square was presented inside the box, the participant was instructed to press a key as soon as it was detected. While the results showed that there were no significant effects of caffeine on

performance, the trend of caffeine improving performance was consistent with previous findings (Smith et al., 1997).

In contrast to experiments that investigate the vigilance task performance of randomized groups of participants, a study conducted by Amir et al. (2001) investigated the effects of caffeine on vigilance in introverted and extraverted non-coffee drinkers. The researchers used a within-subjects design; they tested participants once with a caffeinated coffee and on another occasion with a decaffeinated beverage. Contrary to their hypothesis, they found that caffeine influenced the performance of both groups. Specifically, the results showed that caffeine had a positive effect on vigilance performance, however there did not appear to be a significant effect on personality type or an interaction between caffeine and personality type.

Another study by Schneider et al. (2006) was conducted to determine the impact of the expectation of consuming caffeine on reaction time. One part of the experiment involved telling half of the participants they were going to be given a caffeinated beverage but instead they were provided with decaffeinated coffee. The other half of the participants were given decaffeinated coffee and were not mislead about the contents of their beverage. The results demonstrated an increase in awareness in the misinformed group. In a second experiment, the researchers provided two groups with caffeinated orange juice, but only one group was told about the true contents of the drink. It was hypothesized that participants given the true information would show a greater effect on reaction time when compared to participants given false information. The results demonstrated a very small effect that was not significant. The researchers concluded that future studies should be conducted in order to allow for a broader assessment of these effects (Schneider et al., 2006).

The present experiment employed a between-subjects design to compare the reaction times of participants given either caffeinated coffee or decaffeinated coffee before being asked to complete a series of three computer tests using the program called PEBL2. The first two of these tests (called Oddball and Path Memory) were employed as distractors in order to avoid expectancy effects in participants. The third test was a psychomotor vigilance test, called PPVT. This test measured the speed and accuracy with which participants reacted to a specific stimulus (hitting the spacebar when the X symbol appeared, as opposed to another symbol) during a boring task. The purpose was to measure the ability to maintain vigilance during a reaction time task. Given previous research demonstrating that placebo effects can occur with caffeine (e.g., Schneider et al., 2006) a double-blind procedure was used in the present experiment. With previous studies showing either significant effects of caffeine on reaction time (e.g., Amir et al., 2001) or trends in that direction, it was expected that the ingestion of caffeinated beverages would result in participants having faster reaction times in comparison to those in the non-caffeinated group.

Method

Participants

The participants' ages range from 19 to 70 years with a median age of 30.5 years. Participants were friends and family of the experimenters who agreed to participate in the study. There were 11 females and 9 males.

Materials

The materials used for this experiment were fairly simple. PEBL2 software was used to administer the tests. PEBL is an open source software program that allows researchers to design and run psychological experiments. From the program three psychological tests were selected:

Oddball, Path Memory and Psychomotor Vigilance Task (PPVT). Oddball is a continuous performance test thought to involve prefrontal strategy updating. For Path Memory, a random design is drawn across a grid, after which it disappears, and the participant is asked to redraw the path as closely as possible. PPVT a simple reaction time test in which a circle stimulus appears at delays between 2 and 12 seconds at which time the participant must press the space bar as quickly as possible. The coffee was Starbucks coffee and the cups used were disposable Starbucks cups. A timer was employed to ensure that the tests did not run past the 5-minute mark.

Procedure

Participants were required to sign consent forms, which explained what was required (the experiment involved partial-disclosure to minimize reactivity). Participants were then tested either individually or in pairs. All participants were questioned before testing to ensure they had not yet consumed any caffeine before commencing the experiment. Any participant that had already consumed caffeine that day was not tested.

Each cup was filled with 300 mL of either caffeinated or decaffeinated coffee. The researcher provided two cups, identical in appearance, to the participant. Each cup was marked on the bottom to indicate which was coffee and which was decaf. The researcher placed both beverages in front of the participant and turned around while the participant moved the cups around. In this way, neither the researcher nor the participant knew which coffee cup contained the caffeine; which allowed for a double-blind study.

After consuming their beverages, participants were immediately asked to complete three tasks. Each task was administered for 5-minutes using the PEBL2 computer software. Participants were told that the total number of correct responses was being measured when in

fact reaction time/vigilance was being tested. The first two tasks were included to reduce reactivity as well as provide a 15-minute waiting period in which the caffeine could fully take effect. Oddball and Path Memory were conducted for 5-minute periods. Five minutes were allowed between tests so that there was a delay of 15 minutes before starting the third test, PPVT; by this time the participants that consumed caffeine should have been feeling the effects of the stimulant. The PPVT test was the only test for which results were recorded.

After completing the three tasks, the participants were debriefed. A detailed review of the partial disclosure used in this experiment was provided, as well as a description of what the research was actually testing. Each participant was given an opportunity to ask questions or voice any concerns. They were reminded that all results would be anonymous, and their data could be removed from the findings if they so wished. Participants who were given decaffeinated coffee and wanted a cup of caffeinated coffee were provided with a caffeinated beverage at that time.

Results

The level of significance set in this experiment was 0.05. The mean response time for the Caffeinated Group was 388.83 milliseconds (SD = 43.78) and the mean response time for the Decaffeinated Group was 422.33 milliseconds (SD = 81.01). See Figure 1 for a summary of the descriptive statistics. These data were analyzed using a two-tail t-test and the results were not statistically significant, $t(18) = 1.15$, $p = 0.27$, suggesting that there was no difference between the reaction time across the two conditions.

Discussion

The hypothesis investigated in the current report was that participants who received a 300 mL dose of caffeinated coffee would have faster reaction times than those who received a 300 mL decaffeinated control. The findings did not support this hypothesis.

These findings are inconsistent with the past studies demonstrating statistically significant effects of caffeine on reaction time (Amir et al., 2001). Given the results obtained from past studies, it was expected that participants who belonged to the Caffeinated Group would have faster reaction times than those who belonged to the Decaffeinated Group. Despite observing a slight difference between groups, the effect was not sufficient to yield statistical significance.

In conducting this experiment, several factors may have affected the outcome. For example, some participants opted to add milk and/or sugar to their coffee while others did not and participants may have had varied levels of alertness at the beginning of the experimental session. To combat these factors and improve upon this experiment, researchers could have disallowed the addition of milk and sugar to the participants' coffee and could have tested all participants at the same time of day in anticipation that all participants would have the same relative alertness.

Concerning external validity, a larger sample size may have generated results more reflective of the general population, with the potential of obtaining statistical significance. A larger sample size is therefore recommended for any future research on this topic.

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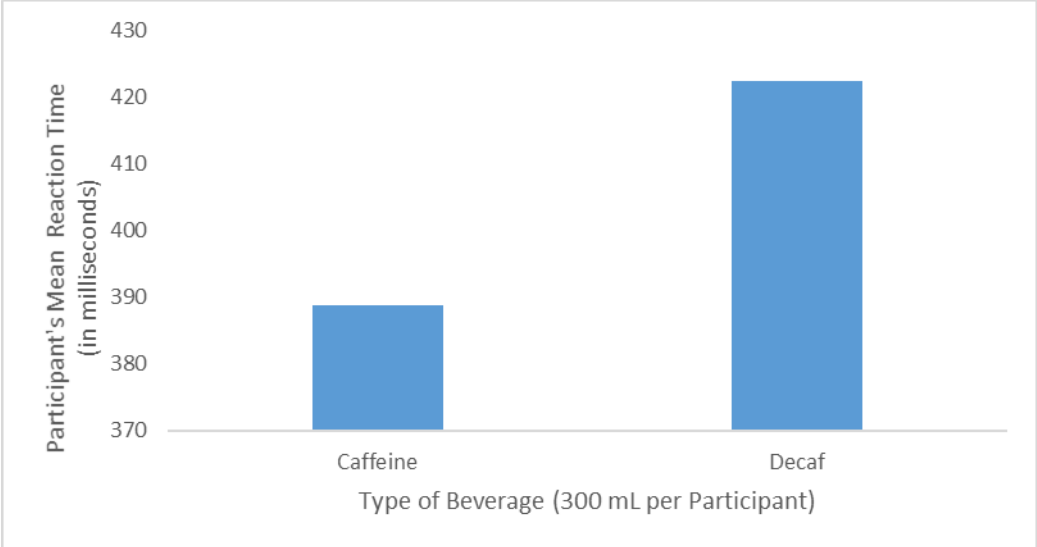

Figure 1. Mean reaction time test scores for participants in the Caffeinated and Decaffeinated Groups.